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(54) **APPARATUS AND METHODS FOR IMPINGEMENT COOLING OF A SIDE WALL OF A TURBINE NOZZLE SEGMENT**

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(*) Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(58) **Field of Search** .... 415/114, 115, 415/116, 117, 138, 139; 416/96 R, 96 A, 97 R

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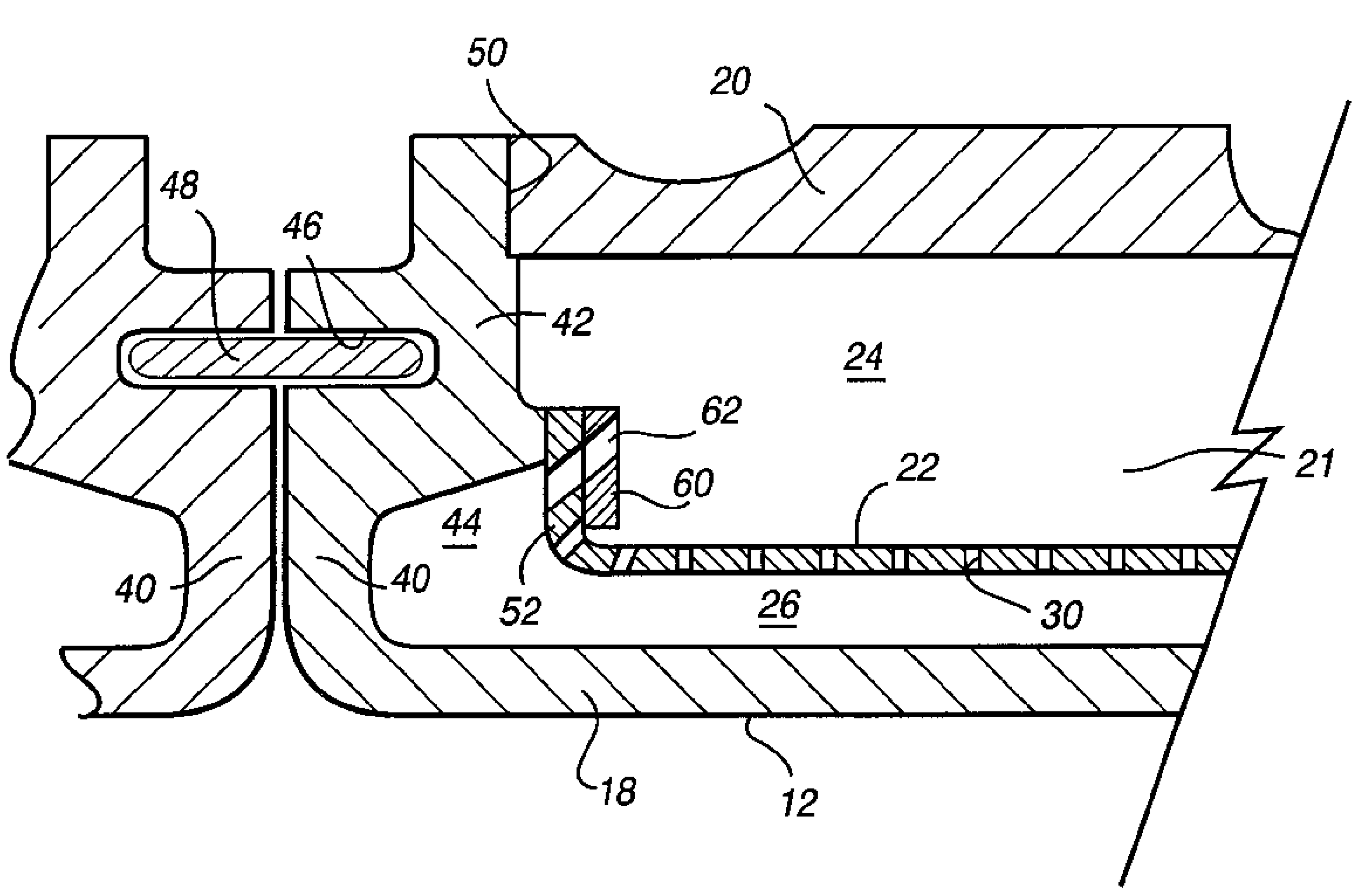
(57) **ABSTRACT**

A gas turbine nozzle segment has outer and inner bands and a vane therebetween. Each band includes a nozzle wall, a side wall, a cover and an impingement plate between the cover and the nozzle wall defining two cavities on opposite sides of the impingement plate. Cooling steam is supplied to one cavity for flow through apertures of the impingement plate to cool the nozzle wall. The side wall of the band and inturned flange define with the nozzle wall an undercut region. The impingement plate has a turned flange welded to the inturned flange. A backing plate overlies the turned flange and aligned apertures are formed through the backing plate and turned flange to direct and focus cooling flow onto the side wall of the nozzle segment.

9 Claims, 2 Drawing Sheets



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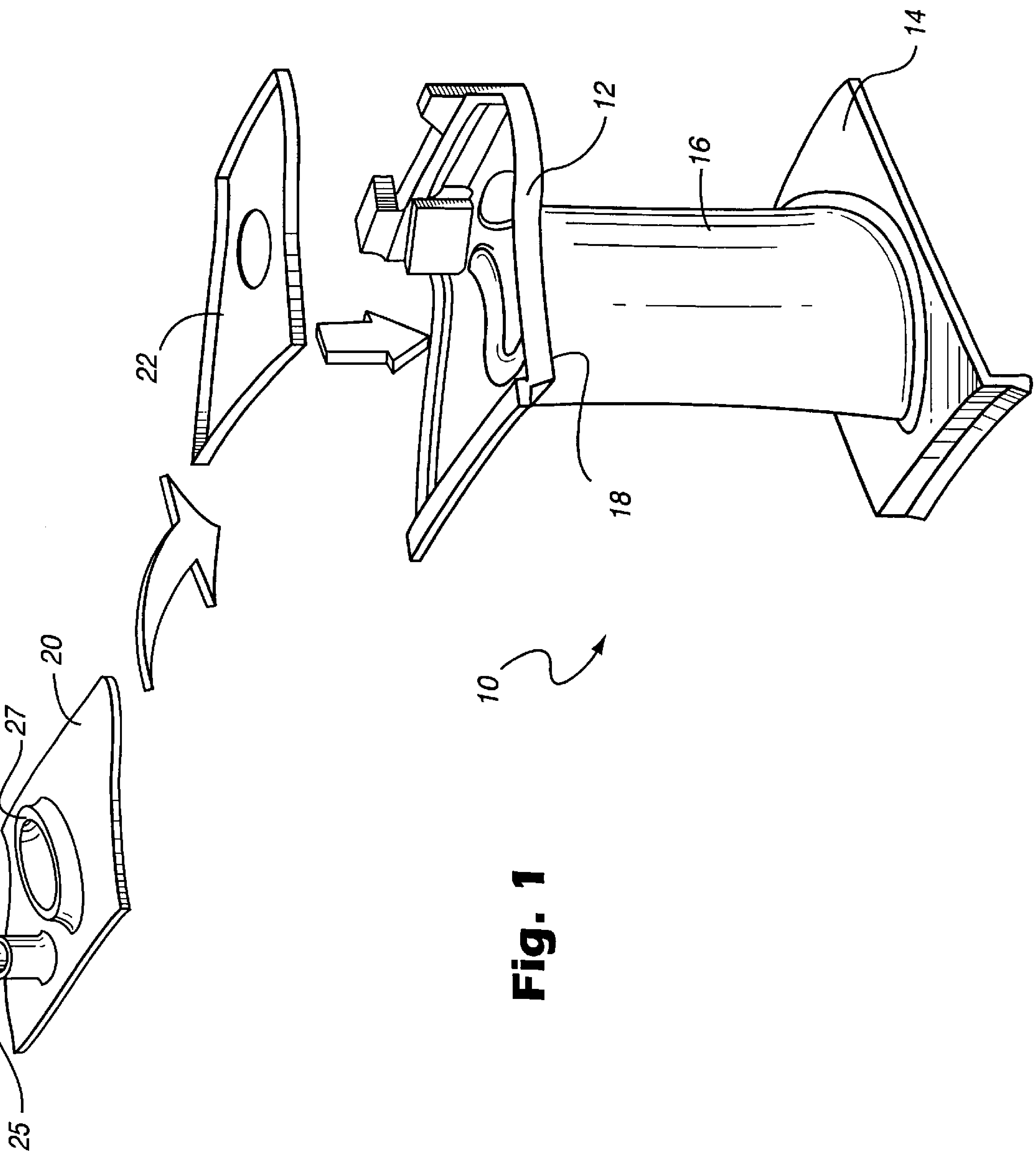

Fig. 1

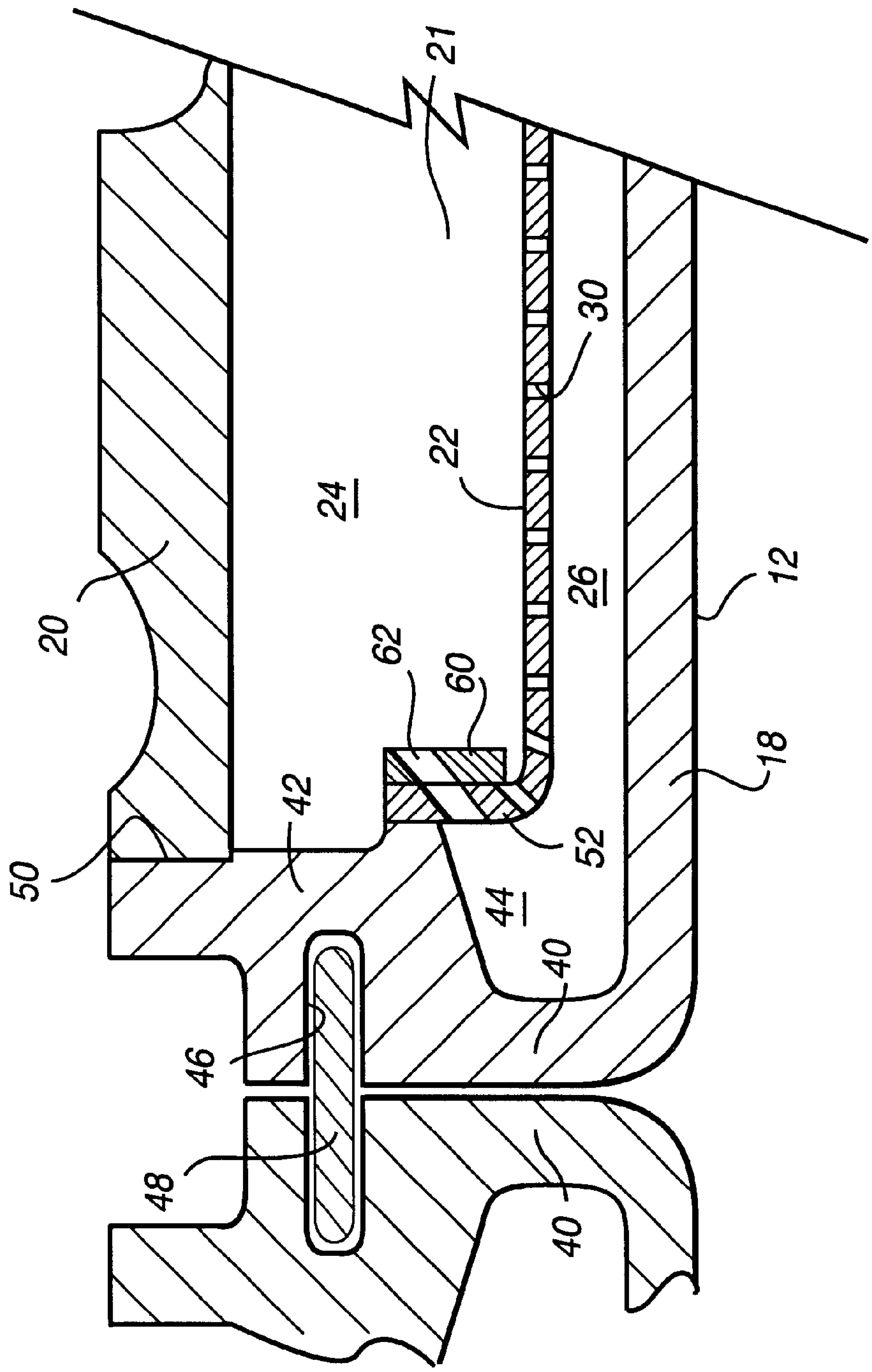

Fig. 2

APPARATUS AND METHODS FOR IMPINGEMENT COOLING OF A SIDE WALL OF A TURBINE NOZZLE SEGMENT

This invention was made with Government support under Contract No. DE-FC21-95MC311876 awarded by the Department of Energy. The Government has certain rights in this invention.

BACKGROUND OF THE INVENTION

The present invention relates to impingement cooling of a gas turbine nozzle band side wall of a nozzle segment and particularly relates to impingement cooling of a nozzle band side wall in the undercut region of a nozzle segment wherein the weld joint between the nozzle segment cover and the nozzle side wall is remote from the nozzle wall exposed to the hot gas path.

In current gas turbine designs, nozzle segments are typically arranged in an annular array about the rotary axis of the turbine. The array of segments forms outer and inner annular bands and a plurality of vanes extend between the bands. The bands and vanes define in part the hot gas path through the gas turbine. Each nozzle segment comprises an outer band portion and an inner band portion and one or more nozzle vanes extend between the outer and inner band portions. In current gas turbine designs, a cooling medium, for example, steam, is supplied to each of the nozzle segments to cool the parts exposed to the hot gas path. To accommodate the steam cooling, each band portion includes a nozzle wall in part defining the hot gas path through the turbine, a cover radially spaced from the nozzle wall defining a chamber therewith and an impingement plate disposed in the chamber. The impingement plate defines with the cover a first cavity on one side thereof for receiving cooling steam from a cooling steam inlet. The impingement plate also defines, along an opposite side thereof and with the nozzle wall, a second cavity. The impingement plate has a plurality of apertures for flowing the cooling steam from the first cavity into the second cavity for impingement cooling the nozzle wall. The cooling steam then flows radially inwardly through cavities in the vane(s), certain of which include inserts with apertures for impingement cooling the side walls of the vane. The cooling steam then enters a chamber in the inner band portion and reverses its flow direction for flow radially outwardly through an impingement plate for impingement cooling the nozzle wall of the inner band. The spent cooling medium flows back through a cavity in the vane to an exhaust port of the nozzle segment.

The cover provided in each of the outer and inner band portions is preferably welded to the corresponding nozzle side wall. In prior designs, the weld joint between the cover and the nozzle side wall was disposed at a radial location between the nozzle wall and the spline seal between side walls of adjacent nozzle segments. In that location, the weld was exposed to the high temperature gases in the hot gas flow path and was very difficult to cool. Thus, weld joint fatigue life was significantly reduced due to its proximity to the hot gas path. Moreover, the location of the weld was not optimum for manufacturing repeatability and was very sensitive to manufacturing tolerances. The weld joint was characterized by variable wall thicknesses which increased the stress at the joint, decreased the low cycle fatigue and limited the life of the parts. The wall thickness at the weld after machining was also a variable which could not be tolerated in the manufacturing process.

BRIEF SUMMARY OF THE INVENTION

In accordance with a preferred embodiment of the present invention, a cooling system is provided in a nozzle segment

in which the weld joint between the cover and nozzle wall is on the side of the spline seal remote from the nozzle wall exposed to the hot gas path. That is, the weld joint between the cover and the nozzle side wall of the outer band is located radially outwardly of the spline seal between adjacent outer bands while the weld joint between the cover and the nozzle side wall of the inner band is located radially inwardly of the spline seal between adjacent inner bands. This reduces the temperature of the weld joints during turbine operation, reduces the stresses across the joints, both thermal and mechanical, eliminates any requirement for machining after welding and results in joints of constant thickness and higher fatigue life. The location also leads to improved machinability and tolerance to weld defects.

To provide that weld location, undercut regions adjacent the side walls of the nozzle segment bands are formed. Particularly, each undercut region includes a side wall or edge of the nozzle segment and an inturned flange extending inwardly from and generally parallel to and spaced from the nozzle wall. Cooling the nozzle band side wall or edge, however, is quite difficult in view of the undercut region which distances the side wall or edge from the impingement plate. This large distance reduces the effectiveness of cooling the nozzle side wall by impingement cooling flow through apertures in the impingement plate.

In accordance with the present invention, improved side wall fabrication and cooling is provided. Particularly, with the weld joint between the cover and the nozzle side wall located remotely from the hot gas path through the turbine, side wall cooling is improved by providing a backing plate for the impingement plate with apertures through the backing plate aligned with apertures through the impingement plate for directing impingement cooling flow onto the side wall. Particularly, the impingement plate is provided with a turned edge. Margins of the edge are secured, for example, by welding to the prepared face of the inturned flange of the nozzle segment side wall, leaving a portion of the turned edge of the impingement plate extending generally parallel to the nozzle segment side wall. To more directly target or focus the impingement cooling medium flowing through the apertures of the turned edge, a backing plate having apertures aligned with the apertures through the turned edge of the impingement plate is secured along the turned edge. As a consequence, the length-to-diameter ratio of the aligned apertures is improved, thereby enabling direct targeting or focusing of the cooling flow onto the side wall of the nozzle segment. The backing plate also adds additional strength about the perimeter of the impingement plate.

The foregoing cooling system is readily and easily fabricated. For example, the backing plate is added to the turned flange of the impingement plate and apertures are then provided simultaneously through the backing plate and turned edge. The impingement plate is then placed into the nozzle segment and tacked into position and later welded or brazed into the nozzle segment.

In a preferred embodiment according to the present invention, there is provided for use in a gas turbine, a nozzle segment having outer and inner band portions and at least one vane extending between the band portions, at least one of the band portions having a nozzle wall defining in part a hot gas path through the turbine, a cover radially spaced from the nozzle wall defining a chamber therebetween and an impingement plate secured within the segment and disposed in the chamber defining with the cover a first cavity on one side thereof for receiving a cooling medium, the impingement plate on an opposite side thereof defining with the nozzle wall a second cavity, the impingement plate having a plurality of apertures therethrough for flowing cooling medium from the first cavity into the second cavity for impingement cooling the nozzle wall, the nozzle segment including a side wall extending generally radially between the nozzle wall and the cover and having an inturned flange, the inturned flange defining an undercut region adjacent the side wall, and a backing plate overlying a portion of the impingement plate, the backing plate and the impingement plate portion having aligned apertures therethrough for directing a flow of the cooling medium onto the side wall for impingement cooling thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded perspective and schematic view of a nozzle segment constructed in accordance with the present invention; and

FIG. **2** is an enlarged fragmentary cross-sectional view illustrating a side wall of a nozzle segment and a backing plate and impingement plate for cooling the side wall.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. **1**, there is illustrated a nozzle segment, generally designated **10**, forming a part of an annular array of segments disposed about a gas turbine axis. Each nozzle segment includes an outer band **12**, an inner band **14** and one or more vanes **16** extending therebetween. When the nozzle segments are arranged in the annular array, the outer and inner bands **12** and **14** and vanes **16** in part define an annular hot gas path through the gas turbine, as is conventional.

The outer and inner bands and the vanes are cooled by flowing a cooling medium, e.g., steam, through a chamber in the outer band **12**, radially inwardly through cavities in the vanes, through a chamber in the inner band **14** and radially outwardly through the vanes for return of the cooling medium to an exit port along the outer band. More particularly and by way of example referencing FIG. **1**, the outer band **12** includes an outer nozzle wall **18**, an outer cover **20** which is disposed over and welded to the outer wall **18** to define a chamber **21** (FIG. **2**) therebetween and an impingement plate **22** disposed in the chamber **21**. The impingement plate **22** defines with the nozzle segment cover **20** a first cavity **24** and, on an opposite side thereof, defines with the nozzle wall **18** a second cavity **26**. Cooling medium inlet and outlet ports **25** and **27**, respectively, are provided through the cover for supplying the cooling medium, e.g., steam, to the nozzle vane segment and exhausting the spent cooling steam from the segment. The cooling steam is supplied to the first cavity **24** for passage through a plurality of apertures **30** in the impingement plate **22** for impingement cooling of the nozzle wall **18**. The impingement cooling steam flows from the second cavity **26** into one or more inserts (not shown) in cavities extending through the vane between the outer and inner bands. The vane inserts include a plurality of apertures for impingement cooling of the side walls of the vane. The cooling steam then flows into the chamber of the inner band **14** and particularly into the radial innermost cavity for flow through apertures of an impingement plate in the inner band for impingement cooling the side wall of the inner band. The spent cooling steam then flows through a cavity in the vane and through the exhaust port of the outer band. For a complete description of an embodiment of the foregoing described cooling circuit, reference is made to U.S. Pat. No. 5,634,766, of common assignee, the disclosure of which is incorporated herein by reference.

Referring now to FIG. **2**, there is illustrated a juncture between adjacent nozzle segments. It will be appreciated that while the following description is specific with reference to the outer band **12**, it is equally applicable to the inner band **14**. Thus, each nozzle band (both inner and outer bands) includes a nozzle side wall or edge **40** which extends generally radially between the nozzle wall **18** and the cover **20**. The band also includes an inturned flange **42** spaced from the nozzle wall **18** and defines with wall **18** and side wall or edge **40** an undercut region **44**. The inturned flange **42** also includes a circumferentially opening slot **46** for receiving one edge of a spline **48** forming a seal between adjacent nozzle segments.

As illustrated in FIG. **2**, each cover **20** is welded to the inturned flange **42** along opposite edges of the nozzle band. The weld joint **50** lies on the side of the spline seal **48** remote from the nozzle wall **18**. By locating the weld joint **50** away from the hot gas path defined in part by nozzle wall **18**, the weld joint **50** is subjected to a much lower temperature than if located closer to the hot gas path. Also illustrated in FIG. **2** is the impingement plate **22** which has an flange or turned edge **52** along each of its margins. The turned edge **52** is brazed or welded to an inside surface of the inturned flange **42**. While apertures **30** are located in each turned edge **52** of the impingement plate **22**, it will be appreciated that there is a substantial distance between the nearest aperture **30** and the side wall or edge **40** in the undercut region **44**. This large distance diminishes the cooling effectiveness of the cooling medium flowing through the apertures of the turned flange **52**.

To afford effective impingement cooling of the side wall **40** along the undercut region, a backing plate **60** is provided along one side of the turned edge **52** of the impingement plate **22**. The backing plate **60** is preferably secured to the impingement plate's turned flange **52** prior to securing the impingement plate **22** to the nozzle segment **10**. With the backing plate **60** in place, apertures **62** are formed through the combined backing plate **60** and turned edge **52** and which aligned apertures are directed toward or focused upon the side wall **40**. By increasing the length-to-diameter ratio of the apertures **62** for flowing cooling medium, e.g., steam, from the first cavity **24** into the second cavity **26** by applying the backing plate **60**, the flow through these longer apertures **62** is directed or targeted on the side walls **40** of the nozzle segments. Instead of the cooling medium pattern spreading out, for example, in a conical spray pattern, the cooling medium remains concentrated and focused and coherently traverses the distance between turned edge **52** and side wall **40** to direct the cooling medium onto and thereby effectively cool the side wall. As indicated in FIG. **2**, the length-to-diameter ratio of aligned openings **62** is in excess of the length-to-diameter ratio of apertures **30**.

Preferably, the backing plate **60** is applied to the turned edge **52** of the impingement plate **22**, for example, by welding, prior to attachment of the impingement plate to the nozzle segment. In this manner, aligned apertures **62** through the backing plate **60** and the turned edge **52** of the impingement plate **22** can be formed simultaneously. The impingement plate **22** can then be placed into the nozzle segment and welded or brazed to inturned flange **42** of the nozzle side wall **40**. It will be appreciated that this arrangement is applicable to both the inner and outer bands of the nozzle segment.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. For use in a gas turbine, a nozzle segment having outer and inner band portions and at least one vane extending between said band portions, at least one of said band portions having a nozzle wall defining in part a hot gas path through the turbine, a cover radially spaced from said nozzle wall defining a chamber therebetween and an impingement plate secured within said segment and disposed in said chamber defining with said cover a first cavity on one side thereof for receiving a cooling medium, said impingement plate on an opposite side thereof defining with said nozzle wall a second cavity, said impingement plate having a plurality of apertures therethrough for flowing cooling medium from said first cavity into said second cavity for impingement cooling said nozzle wall, said nozzle segment including a side wall extending generally radially between said nozzle wall and said cover and having an inturned flange, said inturned flange defining an undercut region adjacent said side wall, and a backing plate overlying a portion of said impingement plate, said backing plate and said impingement plate portion having aligned apertures therethrough for directing a flow of the cooling medium onto said side wall for impingement cooling thereof.

2. A nozzle segment according to claim **1** wherein said aligned apertures have length-to-width ratios in excess of the length-to-width ratios of the apertures through portions of the impingement plate not overlaid by the backing plate.

3. A nozzle segment according to claim **1** wherein said impingement plate has a turned edge secured to said inturned flange of said side wall, said backing plate extending along said turned edge of said impingement plate.

4. A nozzle segment according to claim **3** wherein said backing plate lies in said first cavity.

5. A nozzle segment according to claim **3** wherein said turned edge of said impingement plate and said backing plate extend generally in a radial direction.

6. A nozzle segment according to claim **1** wherein said nozzle side wall and said cover are welded to one another at a weld joint on a side of said backing plate remote from said side wall.

7. A nozzle segment according to claim **1** wherein said side wall has a slot opening outwardly of said segment for receiving a spline seal, said side wall and said cover being welded to one another at a weld joint outwardly of said slot.

8. A nozzle segment according to claim **1** wherein said one band portion comprises an outer band of said nozzle segment.

9. A nozzle segment according to claim **1** wherein said one band portion comprises an inner band of said nozzle segment.

* * * * *